PRIORITIES FOR SEED TECHNOLOGY RESEARCH

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In particular, we thank O. L. Justice for his encouragement and advice during this study. We owe much to him and to others including L. E. Everson, T. F. Cuddy, B. E. Clark, D. Isely, and L. Arnold for helpful reviews. Thanks are due also to Frederick A. Waltz, formerly of the Data Systems Application Division, and Roy Heatwole and Edwin Cox, Biometrical Services Staff, who assisted with the analysis.

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American Seed Trade Association (ASTA)
Association of Official Seed Analysts (AOSA)
Canadian Seed Trade (CST)
Commercial Seed Analysts Association of Canada (CSAAC)
Experiment station directors
International Seed Testing Association (ISTA)
National Association of State Departments of Agriculture (NASDA)
Society of Commercial Seed Technologists (SCST)
State Crop Improvement Associations
State extenson workers (on seeds)

Finally, we thank all those respondents who gave so generously of their time and energy in answering the questionnaire. We hope that their efforts will help to solve some of the technology problems.

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By L. W. Woodstock, *leader, Seed Quality Investigations, Market Quality Research Division, and* Dan Niffenegger, *assistant director, Biometrical Services Staff, Agricultural Research Service, United States Department of Agriculture*

INTRODUCTION

High-quality seed is basic to American agriculture. During 1968, the farm value of field and vegetable crops planted from seed was $20.6 billion. Estimates of loss of productivity due to one or another aspect of seed quality range from 5 to 10 percent of the potential yield. Another 1 to 2 percent is lost because information needed to determine factors such as optimum planting date and planning rate is not available at time of planting. Reduction of seed-associated crop losses, therefore, could lead to benefits as high as $2.5 billion a year.

The production, processing, and marketing of seeds altogether constitutes a billion dollar industry in the United States. Seedsmen, distributors, wholesalers, State and Federal regulatory officials, certifying agencies, and others are essential in maintaining a high standard of excellence. All these groups depend on an active program of seed technology research to solve critical problems that arise and interfere with the efficient production or marketing of high-quality seed. Some problems and associated research needs change from year to year whereas other problems have vexed seedsmen for decades. Furthermore, the nature of the problem varies greatly from group to group.

In 1967, the Association of Official Seed Analysts (AOSA) published a pamphlet entitled, "Seed Technology Research in North America."[1] One section in that pamphlet listed research needed in seed technology, but did not specify any priorities. A questionnaire was, then, circulated as a fair way of obtaining ideas as to the relative importance of different research projects. Replies to this questionnaire were evaluated and the results reported here.

Priorities were thus established for the different types of research listed in the AOSA report for the different groups concerned with one or more aspects of seed production or marketing. To make the survey as comprehensive as possible, over 1,500 questionnaires were distributed through the 10 cooperating associations (see acknowledgments). The study reported here is based on 515 replies received by August 1, 1969 (appendix table 1).[2] Considering the number of replies and diversity of the groups involved, this study represents the most comprehensive survey of research priorities in seed technology conducted to date.

This study may be of use to the following groups. Administrators can use it to determine the relative demand for different kinds of seed research. This can be done either for the overall priority assigned by all respondents or by particular groups of respondents; that is, commercial seedsmen vs. regulatory officials, or administrators vs. research scientists. Conversely, research scientists can determine which groups are potentially the most interested in their projects or their area of research. Finally, the study may help long-range planners in industry, university, and Government to identify those areas where increased research effort may be most desirable.

[1] Association of Official Seed Analysts Research Committee, Research Survey Subcommittee. seed technology research in north america. (American Seed Research Foundation cooperating.) 1967.

[2] A preliminary report, based on 428 replies received as of May 9, 1969, appeared in the AOSA Newsletter, vol. 43, No. 3.

METHODS

The Seed Technology Research Questionnaire covered nine major research areas, corresponding to broad fields of study; 46 subsections of intermediate level; and 175 specific projects. The subsections and specific projects were taken from the pamphlet, Seed Technology Research in North America (see reference listed in footnote 1), with editing and rearranging to eliminate duplications. This system allowed us to determine relative priorities at three levels of hierarchy. However, the specific projects varied greatly in scope. With only small changes in emphasis, some projects might have been placed in any one of two or three broad areas.

The questionnaires were mailed in envelopes with return glassine envelopes. The return address, printed on the reverse side of the questionnaire, could be torn out along a perforated edge. To ensure better response, qusetionnaires usually accompanied by a covering letter from an official of the association were mailed to individuals by their respective associations.

Respondents were asked first to indicate the primary organizational affiliation of their laboratory, the classification and main function of their laboratory, and their position (see appendix, exhibit 1). Respondents were then asked to rank the major research areas from 1 to 9 in order of importance, with 1 indicating the most important area (exhibit 2, col. I). Finally, they were asked to choose the five specific projects in each major research area that they considered to be most important and to rank these in order of importance (exhibit 2, col. III through VII). Response boxes were coded so that the completed questionnaires could go directly to key punch operators to prepare for analysis by computer.

Some questionnaires were incorrectly completed when first received, with either the ranking of major research areas or the selection of specific projects missing. Such questionnaires were returned to the respondents for completion; usually, the corrected forms were received within a few days. As much information as possible was obtained from a few questionnaires that were not corrected in entirety by respondents. The most frequent error was incomplete ranking of major research areas. The respondent would rank 4, 5, or 6 major areas leaving the others unranked. The rules followed in making corrections were (1) to distribute the remaining unspecified ranks evenly among the unranked areas and (2) to select the assigned rank for the unranked areas such that the total of all ranks on each form always equaled $1 + 2 + 3 \ldots + 9 = 45$. For example, if ranks 1, 2, 3, 4, and 5 were given to five major research areas, but the remaining four areas were left unranked, they were each assigned the rank of 7.5.

Major research areas were given 9 points for each first choice, 8 points for each second choice, and so on (exhibit 3). The total number of points for each area was calculated for different groupings of respondents. The research areas with highest total numbers of points were considered to be of highest priority in the group under consideration. With this scoring system, research area scores could be listed from high to low. It is tempting to want to assign highest priority to the area having the highest score, second highest priority to the area having second highest score, and so on. However, such a system of ranking can be quite misleading. Whereas, there is usually no doubt that the area having the highest score is considered to be more important by the respondents than the area having the lowest score; there may be doubt whether a significant priority difference exists between areas that scored, for example, fourth and fifth.

In determining priority ratings of the major research areas, average scores of each major research area and the approximate 95 percent confidence interval of each average score were calculated as follows:

Confidence interval $= \bar{x} \pm (t_{0.05})\, s_{\bar{x}}$
where $\bar{x}$ = mean score
$s_{\bar{x}}$ = standard error of the mean score
$t_{0.05}$ = student's t value for (n-l) degrees of freedom

Each calculated average score was considered to be an estimate of a true, but unknown, average score that would be obtained if all persons

in the group (such as all AOSA members and all research scientists) submitted properly completed questionnaires. We can be 95 percent sure that the true average score lies within the confidence interval. Average scores of major research areas were not considered to be significantly different if overlapping of confidence intervals occurred. Calculations for all 515 replies are given in table 2. Similar calculations for specific groups of respondents are available from the Reference Library, Division of Acquisitions, National Agricultural Library, Beltsville, Md. 20705, upon request (exhibit 4).

In the other tables dealing with major research areas, we gave some indication of those areas which might, with some justification, be regarded as being of high priority. This was done as follows: High priority major research areas were defined as those areas that ranked first or second and those areas from which average scores were not significantly different from the average score of the second ranked major area. They are indicated as shaded areas in tables 3 to 6.

The number of points assigned a specific project depended on (1) the rank of the major research area under which it was listed and (2) the ranking assigned to the five chosen specific projects; that is, first to fifth choice (exhibit 5). This scoring system was based on the assumption that more weight should be given to those projects in areas which respondents listed as high-priority areas than to projects listed in low-priority areas. Total number of points for each specific project was calculated for each group of respondents. The points for all specific projects in each subsection were pooled and subsections were ranked from 1 to 46 on the basis of their cumulative scores.

The top scoring three specific projects within each major research area and other specific projects scoring high in some respondent groups were also determined (exhibit 6). Here, the score depended only on the ranking assigned to the specific project; that is, first choice—5 points, second choice—4 points, and so on, since comparisons between major research areas were not involved.

RESULTS AND DISCUSSION

Response to the Questionnaire

Response to the questionnaire, based on the number of correctly completed questionnaires returned to the number of questionnaires mailed, ranged from 11 percent for the American Seed Trade Association (ASTA) to 85 percent for the AOSA (table 1).[3] Overall response was slightly over 33 percent. This was a very good response considering that a minimum of 2 hours was estimated as necessary to complete the questionnaire.

Because a concerted effort was made to reach all persons concerned with seed testing, some persons received questionnaires from more than one source. This duplication reduced the apparent percentage response. In AOSA, for example, at least three questionnaires were mailed to all member laboratories, even though some laboratories did not have a staff of three. At least one completed questionnaire was received from each AOSA laboratory.

Approximately 25 percent of the respondents made additional comments about needed research and some 10 percent sent covering letters. This response, reflecting the willingness of so many individuals to give their time and energy, indicates a great interest in and need for research in seed technology.

Questionnaires were completed by persons representing 256 combinations of primary organizational affiliation, laboratory classification, laboratory function, and position of respondent (exhibit 1). Separate analyses were made for 24 of these combinations (exhibit 8) all of which contained at least 34 respondents. Results are shown in tables 2–6 for these combinations including: Four organizations, four laboratory classifications, four laboratory functions, four respondent positions, three subgroups within AOSA, four groupings of other, and the composite of all available data.

[3] For a complete list of organizational names and abbreviations, see Acknowledgments.

Tabulated results giving the 95 percent confidence intervals for scores of major research areas and all specific projects as determined by each of the 24 groups of respondents are on permanent file in the Reference Library, National Agricultural Library, Beltsville, Md. (exhibit 4).

Major Research Areas

The composite ranking of the major research areas by all respondents is given in table 2. Germination was ranked first among the major research areas. It scored 12,665 points (total cumulative score for all 515 replies). The range for the other eight major research areas was 5,332 to 7,265. The ranking for the nine major areas follows:

Ranking	*Major research area*
1	Germination
2	Sampling and tolerances
3	Supplemental measures
4	Varietal purity
5	Analytical purity
6	Storage
7	Production and processing
8	Pathology
9	Equipment

These results clearly show that germination research was considered highest priority among the broad areas of research. This was true not only when replies for all groups were pooled to give composite values, but also was true for every major group of respondents.

The ranking in table 2 must be taken with several important reservations. First, the ranking of all major research areas after germination varied greatly from group to group. Thus, a high ranking by one group of respondents might be obscured by low rankings of other groups. Second, differences in rankings were not always statistically significant. In some major areas, for example, supplemental quality measures and analytical purity, average scores were identical. When this occurred, the areas were listed in order of their total scores.

Rankings of subsections within major areas varied markedly. Frequently, a low ranking area contained one or more subsections assigned a high priority rating. Conversely, subsections with low ratings were found in high-ranking major areas. Similar disparities between subsections and specific projects also were observed. For this reason any conclusions based only on the ranking in table 2 would be rather superficial. All three levels of hierarchy —broad, intermediate, and specific—must be considered for each of the different groups of respondents to obtain a comprehensive picture of research needs in seed technology.

There were striking differences in priorities assigned by different groups of respondents: analytical purity was ranked second by AOSA and Society of Commercial Seed Technologists (SCST), but ninth by ASTA; whereas storage was ranked second by ASTA, but eighth by AOSA (table 3). Production was third for ASTA, but ninth for AOSA. Varietal purity ranked fourth by AOSA, but eighth by ASTA and SCST. Both SCST and Commercial Seed Analysts Association of Canada (CSAAC) agreed with AOSA in ranking analytical purity second, but agreed with ASTA in ranking varietal purity eighth. The reason for such rankings may be that members of SCST are involved in making purity analyses but ordinarily do not test for varietal purity.

The differences between AOSA and ASTA roughly paralleled those between regulatory and seed company laboratories (table 4). No doubt, they reflect the difference between those in private industry who test seeds in connection with quality control during production or marketing and those in Government, both Federal and State, who are responsible for enforcing seed laws. Seed storage emerges as a major concern of seed producers and distributors, but is of little direct concern to regulatory testers. Developing techniques for analytical purity is a major concern in regulatory testing, but it is of less urgency for seed companies (that are probably concerned with preventing or eliminating contamination.)

One finding of particular interest was that a wide divergence existed between research scientists and other groups (table 4). Research scientists tended to place greater emphasis on projects that could be studied by biochemical, physiological, and pathological techniques. Differences between research scientists and other groups were especially marked within the

AOSA; for example, eight vs. three (storage) and two vs. eight (analytical purity) for all AOSA replies and research scientists, respectively (table 5). In fact, the priorities given by research scientists in AOSA were more like those given by ASTA respondents than like their fellow AOSA respondents. Such priorities may indicate that, in general, ASTA respondents were more interested in projects involving basic biological research than were AOSA respondents.

Because other groups concerned with seed technology depend on the research scientist to solve their problems, these rather marked differences in priorities are a matter of concern. Whether this discrepency reflects that a lack of communication exists between scientists and other groups, that scientists prefer familiar research techniques, that priorities of other groups are behind times, or that scientists are failing to come to grips with the real problem is not clear. Whatever the reason, increased efforts to interest scientists with appropriate skills in seed technology problems seem to be in order.

Seed technologists likewise differed from other groups in their priorities for seed research (table 4). They ranked analytical purity higher and storage lower than did administrators or research scientists. However, seed technologists were in close agreement with the official AOSA replies (data for official replies were tabulated and are available upon request). Since the official group generally consists of laboratory heads, we can assume that agreement between seed technologists and their supervisors is good, perhaps because most of the laboratory heads in AOSA started their careers as seed technologists.

Many respondents did not indicate an organizational affiliation. They are listed as other (tables 1 and 6). Most of these respondents were associated with extension work. Priorities assigned by other respondents closely paralleled those for State experiment stations. Differences between administrators, research scientists, and extension workers were less marked than with AOSA. The reason for this may be that workers in this area had to make rather arbitrary decisions whether they were primarily administrators, research scientists, or extension workers. In AOSA, by contrast, these lines of division may be more apparent.

Research priorities for 34 respondents from International Seed Testing Association (ISTA) are included in table 3 as a check group from outside North America (mostly Europe). ISTA respondents serve in the same general capacity as their AOSA counterparts. The rankings for AOSA and ISTA were roughly the same, but ISTA gave higher priority to storage and lower priority to analytical purity than did AOSA. Surprisingly, ISTA respondents, who must perform routine seed health tests, gave the same priority (7th) to pathology as did AOSA respondents, who do not perform routine health tests.

Specific Projects

All 515 replies.—The 10 highest scoring specific projects for all 515 replies are listed below.

Specific project[1]	*Score*[2]
1. Determine how seeds react to environment during germination	(B4)—5,341
2. Develop sampling methods for modern processing procedures	(A5)—5,197
3. Standardize interpretation of normal vs. abnormal seedlings	(B9)—5,125
4. Develop way of measuring seed vigor	(C5)—4,612
5. Develop tests for rating deterioration and vigor	(C3)—4,607
6. Locate source of variation in germination tests	(B6)—4,492
7. Relationship between germination test and field performance	(B22)—4,373
8. Divider to extract representative sample of desired size	(F1)—4,358
9. Determine best methods for sampling bagged seed	(A3)—4,340
10. Develop simple tests for detection of bacteria, fungi, and viruses	(E3)—4,100

[1] Specific projects are paraphrased for brevity. These projects as originally cited in the questionnaire may be found in exhibit 6 (letters and numbers in parentheses indicate location), p. 15.

[2] Mean score per project = 1,734; range = 158–5,341.

Of the 175 specific projects, the 10 listed here are of very high priority to a broad segment of those concerned with seed technology research. Four of the projects (1st, 4th, 5th, and 7th) were concerned with some aspect of seed vigor.

If the scores for these four projects were combined, vigor would emerge as the greatest single area of concern—in agreement with ranking of the subsections. Variation in test results is another major concern to all groups. Research to locate the sources of variation in germination tests scored sixth in 175 projects. The second, eighth, and ninth projects were also concerned with variability, from the standpoint of getting representative samples.

Research on how seeds react to changes in environmental variables during germination scored highest among the 175 projects. This is an area of study amenable to attack by existing methods of biological research. However, the third ranking project, developing ways to standardize interpretation of normal vs. abnormal seedlings, offers more difficulties. At present, trained analysts, on the basis of their experience, do this interpretation. Considering the many different kinds of seed tested, the many kinds of abnormalities encountered, and the variation in test procedures permitted by the AOSA rules, it seems that the subjective evaluation of seedlings on the basis of experience will not be easily replaced by establishing objective numerical criteria.

Although we have referred to all 175 items at this level as specific projects, they vary greatly in scope. Some projects are so broad that many scientists could devote their entire careers to studying facets of the problem. Others are much more narrow in their scope. Similarly, some projects affect all aspects of seed technology whereas others affect only certain aspects of it.

Respondents generally selected specific projects within a subsection that were broad in scope. For example, in the area supplemental measures, respondents gave the project, "Develop tests which will result in an accurate rating of deterioration and vigor," 4,607 points, while the project, "Develop tests for measuring tolerance of seeds to saline and drought conditions," only scored 199 points. In the area pathology, the project, "Develop simple, rapid, reproducible laboratory tests for detection of bacteria, fungi, and viruses," scored 4,100 points, while "Determine the differences between easily confused fungi such as *Pellicularia filamentosa* (*Rhizoctonia solani*) and *P. practicola* of beans," scored only 177 points.

However, do not conclude that the more specific projects are unimportant. It is not feasible, usually, for a researcher to study broad projects. For example, he cannot develop seed health tests in general; rather, he must begin with some specific aspect of the problem. Furthermore, even a low ranked project might be of sufficient importance to justify research effort. When we consider overall potential benefits from seed technology research to be some $2.5 billion, even a small fraction of this represents a major savings. It would indeed, therefore, be too bad if most researchers rushed to do high ranking projects to the detriment of other projects that were lower priority, but were, nevertheless, important.

AOSA.—The 10 highest scoring specific projects for AOSA are listed below, 191 replies.

Specific Project	*Score*[1]
1. Divider to extract representative sample of desired size	(F1)—2,264
2. Standardize interpretation of normal vs. abnormal seedlings	(B9)—2,160
3. Mechanize the purity test	(I5)—2,088
4. Develop way of measuring seed vigor	(C5)—1,938
5. Locate source of variation in germination tests	(B6)—1,862
6. Determine best methods for sampling bagged seed	(A3)—1,803
7. Manual prescribing methods for testing varietal purity	(G2)—1,768
8. Develop simple tests for detection of bacteria, fungi, and viruses	(E3)—1,763
9. Relationship between germination test and field performance	(B22)—1,732
10. Methods of protecting analysts from chemical fumes	(F11)—1,694

[1] Mean score per project = 691; range = 11–2,264.

Many of the projects listed for all 515 replies are also listed here. AOSA scored "Divider to extract representative sample of desired size" first, and "Standardize interpretation of normal vs. abnormal seedlings" second out of all 175 specific projects. "Mechanize the purity test" was scored third, and "Develop simple tests for detection of bacteria, fungi, and viruses," eighth.

ASTA.—The 10 highest scoring specific projects for ASTA follow, 106 replies.

Specific Project	*Score*[1]
1. Determine how seeds react to environment during germination	(B4)—1,581
2. Develop sampling methods for modern processing lines	(A5)—1,232
3. Develop tests for rating deterioration and vigor	(C3)—1,148
4. Study effect of chemical treatments on seed longevity	(H3)—1,145
5. Optimum temperature and humidity for bulk storage	(D2)—1,116
6. Influence of preharvest environment on seed quality	(H5)—1,094
7. Locate source of variation in germination test results	(B6)—1,011
8. Standardize interpretation of normal vs. abnormal seedlings	(B9)— 995
9. Develop tests for detecting incipient deterioration	(D4)— 989
10. Stress storage test for predicting seed storability	(D11)— 975

[1] Mean score per project = 319; range = 12–1,581.

Again many of the projects are the same as those for all 515 replies. "Determine how seeds react to environment during germination," and "Develop sampling methods for modern processing lines," scored first and second, respectively, out of the 175 projects. Concern of the seed industry for production aspects of seed technology is shown in the fourth and sixth projects. The third, fifth, and ninth projects show the importance which the seed industry attaches to vigor and storage research.

SCST & CSAAC.—The 10 highest scoring specific projects for SCST and CSAAC are listed below, 65 replies.

Specific Project	*Score*[1]
1. Standardize interpretation of normal vs. abnormal seedlings	(B9)—713
2. Locate source of variation in germination test results	(B6)—687
3. Divider to extract representative sample of desired size	(F1)—665
4. Develop sampling methods for modern processing procedures	(A5)—649
5. Determine ways of breaking dormancy	(B15)—598
6. Periodic assessments of variation in germination and purity	(A15)—597
7. Mechanize the purity test	(I5)—578
8. Determine best methods for sampling bagged seed	(A3)—572
9. Relationship between germination test and field performance	(B22)—568
10. Develop way to determine *Poa annua* in Kentucky bluegrass	(F12)—554

[1] Mean score per project = 204; range = 4–713.

"Standardize interpretation of normal vs. abnormal seedlings," and "Locate source of variation in germination test results," ranked first and second, respectively. Sampling is a major area of concern for these groups as shown by the third, fourth, and eighth ranked projects. The second and sixth ranked projects attest to the great concern for reproducibility of test results.

It can be argued with some justification that respondents were asked only to select the five top projects in each major area of research and that had they selected the top 10 from among all 175 projects, we might have had different lists of projects. These tabulations, therefore, are to be regarded as highlighting 10 specific projects of extremely high priority for each of four groups of respondents. They are presented as an aid to the reader. The listings are not exclusive because 10 was an arbitrary cut off number and projects scoring below those listed can still be regarded as high priority. Also, other methods might have led to different listings.

High-ranking projects in each major research area.—The preceding scores of specific projects were determined both by how they were ranked within a major research area and by how highly the major research area itself was ranked. This method allowed comparisons of the relative importance of specific projects in the various major research areas. However, determining how the specific projects ranked when they were compared only with other specific projects within the same research area is also interesting. For example, a seed pathologist might be more interested in learning which projects in his field of competence were of high priority than how seed pathology projects compared with engineering (equipment) or mathematical (tolerances) problems.

The top scoring three specific projects within each major research area are listed in the appendix, exhibit 6. Other projects scoring high in some respondent groups are also listed. Nearly all of the projects ranked among the top 10 by one or more respondent groups are also listed among the top three projects in each research area in exhibit 6. These projects are listed here as originally given in the questionnaire. Several specific projects listed among the top projects under major research area did not score high enough to rank among the top 10 projects when all major areas were combined, but were still of relatively high priority.

Subsections (Exhibit 7)

In the questionnaire, the major research areas were divided into subsections that were in turn divided into one or more specific projects. Subsections, therefore, represent a level of hierarchy intermediate between major research areas and specific projects.

As with the major research areas and specific projects, the reader must keep in mind certain reservations about our ranking of the subsections. Respondents did not vote on the 46 subsections directly. Rather, the scores of the specific projects under each subsection were pooled to give composite scores for the subsections which were then ranked from 1 to 46. Had respondents ranked the subsections directly, the rankings might well have been different from those obtained by our methods.

Our justification for including a ranking of the subsections with our report is as follows: In the questionnaire, similar specific projects were grouped into larger units (subsections) that were given titles that were underlined in the text. Respondents could not very well have answered the questionnaire without being aware of subsection groupings. Many readers, including respondents, may now be curious to know how these subsections compared with each other. Furthermore, the subsections provide a level of organization at which general trends in priorities might be comprehended. They give more detail than the nine major areas, but not so much as to obscure the trends. Finally, we believe that consideration of subsection rankings will provide a needed corrective to possible bias which might be introduced if only major research areas or specific projects were considered.

Some of the specific projects were near duplicates of each other and, where this occurred, they might split the vote. An example is, "Develop way of measuring seed vigor," and, "Develop tests for rating deterioration and vigor," which scored 4,612 and 4,607 points, respectively (see p. 16). On the other hand, the number of specific projects per subsection ranged from 1 to 10, and we were concerned whether comparing subsections with different numbers of questions (the ones with more questions might tend to have higher scores) was fair. We believe that bias introduced by pooling specific projects scores into subsections can be counterbalanced by considering the specific projects directly, whereas bias due to vote splitting can be counterbalanced by considering the subsections. We were further resassured while tabulating results by the following:

(1) Respondents were very selective in choosing specific projects and voted their preference as indicated by the great differences in ranking by various groups of respondents.

(2) Often over a tenfold difference appeared in scores between adjacent projects.

(3) Ranks of specific projects in subsections containing only one project (no vote splitting) ranged from first within the research area sampling and tolerances to last within the research area storage. Thus the number of points a specific project received did not appear to be related to the number of other projects within the same subsection.

Subsections are discussed in the order of the major research areas in which they appear (see appendix). Statistically significant differences between rankings are not shown.

Sampling and tolerances.—The subsections in this area were ranked as follows (all 515 replies): Tolerances, 10th; bins, bags, and other containers, 12th; homogeneity, 18th; processing lines, 24th; and other sampling research, 34th. Greatest overall priority in this area was given by SCST and CSAAC. This may reflect the concern by laboratories whose revenue depends on the confidence of clientele over variation in test results arising from sampling

errors. Regulatory testers (AOSA) were more concerned with tolerances, 6th, than with bins, bags, etc., 15th. For seed companies (ASTA), the order was reversed. Seed technologists gave much higher priority to tolerances than did extension workers, research scientists, or administrators. ISTA respondents gave higher priority to homogeniety and lower priority to tolerances than did their North American counterparts.

Germination.—All subsections under germination ranked in the upper half of the 46 subsections, ranging from fifth to 20th (all 515 replies). Greatest interest was in interpretation of seedlings (5th) and physiology and biochemistry of seed germination (7th), with relatively more emphasis on physiology and biochemistry by ASTA (4th) than by AOSA and SCST. Research scientists ranked interpretation of seedlings lower than did other respondents, but ranked physiology and biochemistry higher. Research on germination requirements was ranked higher by AOSA and ISTA than by other groups. Dormancy was ranked very high by SCST, ISTA, and research scientists. The high ranking of research on seed dormancy (primarily a physiological problem) coupled with the lower rankings for physiological and biochemical research assigned by SCST and seed technologists indicates that applied groups will support physiological and biochemical research when tied to a problem directly affecting their work. Variation in results was ranked ninth by Internal Quality Control Laboratories and 11th by Regulatory Laboratories, but only 25th by research laboratories.

Supplemental measures.—The subsection vigor was ranked first in 46 subsections (all 515 replies). All other subsections in this area received relatively low rankings. All groups of respondents ranked vigor research within the top seven subsections and most groups ranked it first or second. The high ranking for vigor reflects concern by all groups for the development of methods for determining as nearly as possible the actual field planting value of seed lots. Quick viability tests was ranked 18th by both AOSA laboratories doing service testing and commercial testing laboratories.

Storage.—Preservation of quality was given highest ranking within this area by all groups, and it was ranked first of all 46 subsections by ASTA. The subsections in this area were ranked as follows (all 515 replies): Preservation of quality (2d); predicting storability (19th), biochemistry of aging (28th), and grain quality (46th). Predicting storability and biochemistry of aging were ranked significantly higher (7th and 8th, respectively) by research scientists inAOSA than by other AOSA groups. Predicting storability was ranked higher (12th) by ASTA than biochemistry of aging (23d). The order of ranking was reversed by other research scientists (25th and 8th, respectively). Grain quality (not really a seed research project) was ranked lowest by AOSA and second lowest by ASTA.

Pathology.—Detection and identification was ranked highest (6th, all 515 replies) in this area by nearly all groups. The other subsections were ranked in the lower half of the 46 subsections, although some were ranked high by certain groups. Action and importance was ranked 11th by other extension workers. Establishment and transmission was ranked high by research-oriented groups. Detection and identification was ranked higher by ASTA and AOSA than by SCST.

Analytical purity.—Separating component parts was ranked much higher (3d, all 515 replies) than other subsections in this area. It was ranked first of the 46 subsections by AOSA and SCST and 10th by ASTA. Generally, AOSA, SCST, and ISTA gave higher rankings to projects in this area than did extension workers, research scientists, and ASTA.

Varietal purity.—Laboratory tests and clarification of problems were ranked eighth and ninth (all 515 replies). The other subsections were ranked lower. Seed technologists and regulatory analysts placed relatively more emphasis on clarification of problems whereas research scientists and service testing personnel placed more emphasis on laboratory tests. AOSA gave significantly higher ranking to these subsections than did ASTA, but ASTA ranked maintaining varietal purity higher than did AOSA (30th vs. 41st, respectively). Greatest interest in laboratory tests for varietal purity was shown by extension workers (4th) and ISTA (4th).

Production and processing.—Seed production (4th) and mechanical damage (17th) were ranked highest in this area. ASTA, extension workers, and research scientists ranked these subsections higher than did other groups. Mechanical damage was ranked eighth by ASTA, reflecting the concern of seed producers on this subject.

Equipment.—Development of purity analysis and germination equipment were ranked highest (15th and 16th, respectively) of subsections in this area. However, groups varied markedly in their research preferences. For example, cleaning and processing equipment was ranked ninth by ASTA, but 35th by AOSA and SCST. Conversely, purity analysis equipment was ranked ninth by AOSA and 10th by SCST, but only 36th by ASTA. AOSA and seed technologists favored purity analysis over germination equipment. The converse was true of ASTA and other respondents.

SUMMARY

- A questionnaire to determine relative priorities for seed technology research among different groups concerned with seed technology was distributed through 10 cooperating associations.
- Priorities were determined at three levels of hierarchy: nine major research areas, 46 subsections, and 175 specific projects.
- Replies totaled 515 as follows: AOSA (191), ASTA (106), SCST & CSAAC (65), and NASDA (15), ISTA (34), and others (104).
- The major research area germination was ranked first among the nine by all groups of respondents.
- The ranking of the other major research areas varied markedly, depending on the responding group.
- Research on vigor and preservation of quality scored first and second, respectively (all 515 replies pooled) in the 46 subsections and were given very high priority by all groups of respondents.
- There was much concern over variation in test results, standardizing the interpretation of normal vs. abnormal seedlings, and sampling problems by all groups.
- Research on how seeds react to changes in environmental variables during germination was the highest scoring in 175 specific projects.
- AOSA and SCST gave relatively more emphasis to analytical purity and to research directly related to improving techniques for routine germination and purity testing, whereas ASTA gave relatively higher priority to storage and production and processing research.
- Research scientists differed markedly from administrators and seed technologists, placing much greater emphasis on basic research projects that could be solved by biochemical, physiological, and pathological techniques, whereas the last two groups were more concerned with the day-to-day problems of sampling, purity testing, and interpretation of seedlings.
- The following information is presented in this report: Rankings of the major research areas for 24 groups of respondents, rankings of subsections for nine groups of respondents, the 10 highest scoring specific projects for four groups, and the three highest scoring specific projects within each major research area.
- The following additional information may be obtained upon request from the Reference Library, National Agricultural Library, Beltsville, Md. 20705:

1. Mean score with 95-percent confidence intervals for the major research areas for each of 28 groups of respondents.
2. Total score, mean score, and 95-percent confidence intervals for the specific projects listed either consecutively from 1 to 175 or arranged by major research area.

APPENDIX

Tables

TABLE 1.—*Response to the questionnaire by specified group*

Group[1]	Number of replies	Percentage of response
AOSA	191	85
SCST & CSAAC	65	52
ASTA	106	11
NASDA	15	25
Other	104	36
ISTA	34	34

[1] AOSA—Association of Official Seed Analysts; SCST—Society of Commercial Seed Technologists; CSAAC—Commercial Seed Analysts Association of Canada; ASTA—American Seed Trade Association; NASDA—National Association of State Departments of Agriculture; Other—respondents not indicating an organizational affiliation; ISTA—International Seed Testing Association.

TABLE 2.—*Scores given to major work areas, 515 questionnaires*

Major research area	Average[1] score	95-percent confidence interval[2] Lower limit	Upper limit	Ranking
Germination	7.5	7.3	7.6	1
Sampling & tolerances	5.1	4.9	5.3	2
Varietal purity	5.0	4.7	5.2	3
Storage	4.9	4.7	5.1	4
Supplemental measures	4.8	4.6	5.0	5
Analytical purity	4.8	4.6	5.1	6
Production	4.7	4.5	4.9	7
Pathology	4.2	4.0	4.4	8
Equipment	4.1	3.9	4.3	9

[1] Values sharing the same vertical line are not significantly different.

[2] Confidence interval $= \bar{x} \pm [t_{0.05,(n-1)}] s_{\bar{x}}$.

TABLE 3.—*Priorities for major research areas by organizational affiliation*

Organizational affiliation	Number of responses	Ranking (1-9)[1] Sampling & tolerances	Germination	Supp. measures	Storage	Pathology	Analytical purity	Varietal purity	Production & processing	Equipment
AOSA	191	**3**	**1**	5	8	7	**2**	4	9	6
ASTA	106	4	**1**	5	**2**	6	9	8	**3**	7
SCST & CSAAC	65	**3**	**1**	4	5	9	**2**	8	7	6
ISTA[2]	34	2	1	4	5	7	6	3	8	9

[1] High priority (indicated by **boldface**) applies to any work area ranked 1 or 2, or if the average work area score was not significantly different from the average score of the second ranked work area.

[2] Assignments of high priority were made only for groups that had over 50 respondents.

TABLE 4.—*Priorities for major research areas by laboratory classification, laboratory function, and position of respondent*

Responding group	Number of responses	Ranking (1-9)[1]								
		Sampling & tolerances	Germination	Supp. measures	Storage	Pathology	Analytical purity	Varietal purity	Production & processing	Equipment
Laboratory classification:										
State or Federal regulatory	152	3	1	6	8	7	2	4	9	5
Commercial testing[2]	31	3	1	8	5	9	2	4	6	7
Seed company	143	4	1	5	2	8	6	9	3	7
State experiment station	79	7	1	5	4	6	8	2	3	9
Laboratory function:										
Regulatory testing	147	3	1	6	8	7	2	4	9	5
Service testing	79	2	1	7	6	9	3	4	5	8
Internal quality control	126	4	1	5	2	9	6	8	3	7
Research	83	7	1	4	3	5	9	6	2	8
Position of respondent:										
Administrator or lab. head	223	3	1	5	2	9	6	4	7	8
Seed technologist	134	3	1	6	7	9	2	4	8	5
Research scientist	67	7	1	5	3	4	8	6	2	9
Extension worker[2]	37	4	1	6	5	7	8	2	3	9

[1] High priority (indicated by boldface) applies to any work area ranked 1 or 2 or if the average work area score was not significantly different from the average score of the second ranked work area.

[2] Assignments of high priority were made only for groups that had over 50 respondents.

TABLE 5.—*Priorities for major research areas by different groups within AOSA*

Organizational affiliation	Number of responses	Ranking (1-9)[1] Sampling & tolerances	Germination	Supp. measures	Storage	Pathology	Analytical purity	Varietal purity	Production & processing	Equipment
All replies	191	3	**1**	5	8	7	2	4	9	6
Regulatory testing	127	4	**1**	6	8	7	2	3	9	5
Service testing[2]	29	2	1	5	8	9	3	4	7	6
Research[2]	28	6	1	2	3	4	8	7	5	9

[1] High priority (indicated by boldface) applies to any major area ranked 1 or 2 if the average major area score was not significantly different from the average score of the second ranked major area.

[2] Assignments of high priority were made only for groups that had over 50 respondents.

TABLE 6.—*Priorities for major research areas by different groups within other group*

Responding group	Number of responses	Ranking (1-9)[1] Sampling & tolerances	Germination	Supp. measures	Storage	Pathology	Analytical purity	Varietal purity	Production & processing	Equipment
All replies	104	7	**1**	6	4	5	8	2	3	9
Administrators[2]	43	7	1	6	2	5	8	4	3	9
Research scientists[2]	22	7	1	6	4	5	9	3	2	8
Extension workers[2]	26	6	2	5	4	7	9	1	3	8

[1] High priority (indicated by boldface) applies to any major area ranked 1 or 2 if the average major area score was not significantly different from the average score of the second ranked major area.

[2] Assignments of high priority were made only for groups that had over 50 respondents.

Exhibit 1.—Affiliation and Classification of Respondents

1. PRIMARY ORGANIZATIONAL AFFILIATION OF LABORATORY *(Check one) (5-6)* | OTHER *(Specify)*
AOSA-01 ☐ CSAAC OR SCST-02 ☐ ASTA-03 ☐ NASDA-04 ☐ 05

2. CLASSIFICATION OF LABORATORY *(Check one) (7-8)* | OTHER *(Specify)*
STATE OR FEDERAL REGULATORY-01 ☐ COMMERCIAL TESTING-02 ☐ SEED COMPANY-03 ☐ STATE EXPERIMENT STATION-04 ☐ 05

3. PRIMARY FUNCTION OF LABORATORY *(Check one) (9-10)* | OTHER *(Specify)*
REGULATORY TESTING-01 ☐ SERVICE TESTING-02 ☐ INTERNAL QUALITY CONTROL-03 ☐ RESEARCH-04 ☐ 05

4. POSITION OF RESPONDENT *(Check one) (11-12)* | OTHER *(Specify)*
ADMINISTRATOR OR LABORATORY HEAD-01 ☐ SEED TECHNOLOGIST-02 ☐ RESEARCH SCIENTIST-03 ☐ EXTENSION WORK-04 ☐ 05

Exhibit 2.—Research Priorities

5. PRIORITIES FOR RESEARCH *(Read the attachment carefully)*

MAJOR RESEARCH AREA *(Col. II)*
Rank in Column I with numbers 1 thru 9 in order **YOU** regard as most important

SPECIFIC PROJECTS
For each Major Research Area in Column II select five (5) projects **YOU** consider most important (see attachment). Rank these five in order of your choice and enter the project numbers in Columns III thru VII (e.g. a6, a2, a7, a10, a3)

CARD COL.	RANK I	MAJOR RESEARCH AREA II	1ST CHOICE III	CODE 05	2ND CHOICE IV	CODE 04	3RD CHOICE V	CODE 03	4TH CHOICE VI	CODE 02	5TH CHOICE VII	CODE 01	CARD NO. (79-80)
(18-19)		A Sampling and Tolerances	a		a		a		a		a		01
(20-21)		B Germination	b		b		b		b		b		
(22-23)		C Supplemental Measures	c		c		c		c		c		
(24-25)		D Storage	d		d		d		d		d		
(26-27)		E Pathology	e		e		e		e		e		
(28-29)		F Analytical Purity	f		f		f		f		f		
(30-31)		G Varietal Purity	g		g		g		g		g		
(32-33)		H Production and Processing	h		h		h		h		h		
(34-35)		I Equipment	i		i		i		i		i		

MQ FORM T-9 (MAR. 1969) (over)

Exhibit 3.—Scoring Systems for Ranking Major Research Areas

Respondents were asked to rank major areas from 1 to 9:

Rank assigned major area by respondent	*Points scored*
1	9
2	8
3	7
4	6
5	5
6	4
7	3
8	2
9	1

The major area with the greatest number of points will rank 1, the area with the next greatest will rank 2, and so on.

Exhibit 4.—Additional Information

Additional information concerning the results of this questionnaire is on file with the National Agricultural Library, Division of Acquisitions, and may be obtained upon request.

Information on file should be ordered by using the following numbers:

MRA – Average score with 95-percent confidence intervals for the major research areas.

SP – Total score, average score, number of forms, and 95-percent confidence intervals for the specific projects.

Please specify the responding group(s) desired when requesting additional information.

Address inquiries to:

Reference Library, Division of Acquisitions
National Agricultural Library, Beltsville, Md. 20705
Phone 301-345-6200.

Exhibit 5.—Scoring System for Ranking Specific Projects

Each respondent had 675 points to distribute among the various projects as follows:

Rank assigned major areas by respondent	Project and major area weight	Points scored per project				
		First choice 5	Second choice 4	Third choice 3	Fourth choice 2	Fifth choice 1
1	9	45	36	27	18	9
2	8	40	32	24	16	8
3	7	35	28	21	14	7

Exhibit 5.—Scoring System for Ranking Specific Projects—Continued

Rank assigned major areas by respondent	Project and major area weight	Points scored per project				
		First choice 5	Second choice 4	Third choice 3	Fourth choice 2	Fifth choice 1
4	6	30	24	18	12	6
5	5	25	20	15	10	5
6	4	20	16	12	8	4
7	3	15	12	9	6	3
8	2	10	8	6	4	2
9	1	5	4	3	2	1

Exhibit 6.—High-Ranking Specific Projects Listed by Their Respective Major Research Areas[1]

A. Sampling & Tolerances

Top Three Projects

A5. Develop practical methods of sampling seed under various situations associated with modern processing procedures: Seed cleaning, blending, bagging, or other processing steps; from seed in stacked bags; from bags of seed on lift truck platforms; from spouts when seed is being bagged, and from open bags.

A3. Determine which methods of sampling bagged seed are most satisfactory for (a) producing a representative sample, and (b) avoiding serious damage to the seed or the seed container.

A15. Make periodic assessments to locate sources of variation which exist in germination and purity test results so that efforts towards reducing variation will be as effective as possible.

Other Projects Scoring High in Some Respondent Groups

A4. Determine the optimum number of bags to sample for lots of different kinds, sizes, and qualities. ASTA (3d).

A6. Determine the maximum size of a homogeneous lot for seedsmen having limited facilities for mixing as well as for seedsmen who are well equipped for mixing. Service testing laboratories (3d).

A7. Develop a practical procedure for determining homogeneity during processing. ISTA (3d) research laboratories (3d), and Extension workers (3d).

A1. Design sampling tools for bulk lot sampling. Research scientists (3d).

See footnote at end of exhibit, p. 18.

B. Germination

Top Three Projects

B4. Determine how seeds react to changes in temperature, moisture, light, chemicals, and other environmental variables to which they are exposed during germination.

B9. Develop ways to standardize interpretation of normal vs. abnormal seedlings.

B6. Locate and evaluate the magnitude of the source of variation in germination test results.

Other Projects Scoring High in Some Respondent Groups

B22. Determine the relationship between germination test results and field performance with special consideration given to dormant seeds and seeds producing abnormal seedlings. AOSA (3d), ISTA (2d), regulatory laboratories (3d), service testing laboratories (3d), research scientists (3d).

B3. Investigate the physiology and biochemistry of seed during normal and abnormal germination. Research laboratories (1st), research scientists (1st), Extension workers (3d).

B15. Determine ways of breaking dormancy using methods, procedures, and materials now commonly in use in seed laboratories. SCST (3d).

B11. Develop procedures during germination testing to prevent seedling abnormalities that are due to germination testing conditions rather than to weakness of the seeds. Seed technologists (3d).

B5. Describe, enzymatically, the changes in metabolic states that occur upon reactivation of the seeds' metabolic machinery; that is, what happens when a seed germinates? Research laboratories (3d).

C. Supplemental Measures of Seed Quality

Top Three Projects

C5. Develop an acceptable way of measuring seed vigor and a standard system for reporting vigor measurements.

C3. Develop tests that will result in an accurate rating of deterioration and vigor.

C6. Obtain information on the relationships between standard germination tests and other seed quality tests with field performance.

Other Projects Scoring High in Some Respondent Groups

C4. Develop methods for predicting performance of seeds under specified field conditions. ISTA (2d).

C16. Investigate the possibility of using low intensity X-rays, biochemical and/or electronic methods for measuring viability and vigor. Service testing laboratories (3d), Extension workers (3d).

C7. Determine the contribution to ultimate yield by plants grown from seed of different vigor levels. Research laboratories (3d), research scientists (3d).

C10. Develop methods for rapid, accurate evaluation of mechanical injury. Quality control laboratories (3d).

D. Seed Storage

Top Three Projects

D4. Develop tests for detecting incipient deterioration in seed lots before viability actually declines.

D11. Develop a rapid "stress storage" test for predicting seed storability to identify those lots of equal viability which will go out of condition first.

D2. Determine optimum conditions of temperature and humidity for bulk storage of different species.

Other Projects Scoring High in Some Respondent Groups

D15. Encourage studies of the manner in which seeds age and die, leading to systematic adoption of improved storage procedures. AOSA (3d), service testing laboratories (3d), research laboratories (2d), research scientist (1st).

D1. Determine optimum moisture content and temperature when seeds of different species are to be stored in sealed containers for long-term storage of high-value seeds or breeding stock. ISTA (1st), regulatory laboratories (1st), research scientists (2d).

D6. Investigate methods other than the conventional control of temperature and humidity for extending seed storage life. Research laboratories (3d).

D3. Obtain information on conditions essential for preserving seed testing samples in their original state for a period of one year. Regulatory laboratories (3d), seed technologists (3d).

E. Seed Pathology

Top Three Projects

E3. Develop simple, rapid, reproducible laboratory tests for detection of bacteria, fungi, and viruses.

E6. Investigate the practicability of detecting and reporting important disease agents in conjunction with germination testing.

E2. Describe and illustrate micro-organisms and affected seeds seen during testing.

Other Projects Scoring High in Some Respondent Groups

E1. Prepare a list of known disease agents (bacteria, fungi, nematodes, and viruses) occurring with each kind of seed grown or imported into the United States. Administrators (3d), research scientists (3d).

E15. Correlate the level of seed infection with actual incidence of disease in the field. Extension workers (1st).

E12. Determine how disease agents are carried in specific crop seeds, especially those of bean, corn, cotton, sorghum. ASTA (2d).

E8. Relate humidity, temperature, and other factors to the activity and pathogenicity of microorganisms and their establishment in seeds. Research laboratories (3d).

F. Analytical Purity

Top Three Projects

F1. Develop a sample divider which will extract a representative working sample of the desired size after one passage of the seed through the divider.

F11. Develop improved methods for the safe handling of treated seeds and for protecting seed analysis from chemical fumes.

F8. Compare mechanical blowing procedures with the official method of analyzing seed of different grass species for speed, variation, and closeness to "true" quality of the seed.

Other Projects Scoring High in Some Respondent Groups

F5. Make increased use of mechanical aids, such as gravity tables and spiral separators, for seed movement and separations. Research laboratories (1st), administrators (3d), research scientists (1st).

F15. Find new ways to illustrate seed characteristics used in seed identification. Service testing laboratories (3d), seed technologists (3d), Extension workers (3d).

F14. Make further use of the technique of identifying seeds by the use of chemical solutions. Extension workers (2d).

F17. Develop standard criteria for declaring weeds as noxious. ASTA (2d), quality control labs (3d), research labs (3d).

F12. Develop a rapid way to determine the amount of *Poa annua* present in Kentucky bluegrass samples. SCST (2d), service testing laboratories (2d).

F18. Determine whether present weed seed restrictions in seed lots might be made more realistic. (Ninety seeds per pound in one kind of seed may result in one noxious seed per 10 square feet, whereas 90/pound in another kind might lead to only one seed per 300 square feet). Research scientists (2d), Extension workers (1st).

F3. Develop an optical setup which will adequately enlarge 20 to 30 seeds at a time. ASTA (3d).

G. Varietal Purity

Top Three Projects

G12. Search for new chemical, biochemical, and physical methods of assessing varietal purity.

G2. Publish a manual prescribing known methods for testing different kinds of seed for varietal purity.

G3. Publish an authenticated list of variety names and descriptions.

Other Projects Scoring High in Some Respondent Groups

G1. Establish an association-wide policy concerning the extent to which seed laboratories are responsible for determining varietal purity in samples submitted for testing. SCST (3d), quality control laboratories (3d), seed technologists (2d), Extension workers (3d).

G11. Study seed and seedling morphological characteristics in detail to determine which characteristics have value in varietal determination. ISTA (2d), research laboratories (2d), research scientists (3d).

G23. Determine the extent of genetic shift which occurs within a variety grown under various environmental conditions. ASTA (1st).

G22. Develop a procedure, acceptable to both industry and Government, to maintain the identity of privately developed varieties. ASTA (3d).

H. Production and Processing

Top Three Projects

H5. Investigate the influence of preharvest environment on seed germination, vigor, and storability.

H12. Identify the sources of mechanical injury to seed during harvesting, drying, conveying, and processing.

H8. Determine the effect of environmental conditions during seed development and maturation on subsequent seed performance and vigor.

Other Projects Scoring High in Some Respondent Groups

H3. Study the effect of chemical treatments upon the longevity of seeds. SCST (1st), ASTS (1st), regulatory laboratories (1st), service testing laboratories (1st), quality control laboratories (1st), administrators (1st), seed technologists (1st).

H9. Study the chemistry and physics of seed-environment interrelationships in germination, dormancy, aging, and vigor to improve practices in crop production and seed technology. Research laboratories (3d), research scientists (3d).

H4. Determine the factors influencing seed development and maturation. ISTA (2d).

H11. Develop machinery and procedures for the proper blending of seed. SCST (3d), regulatory laboratories (2d).

I. Equipment

Top Three Projects

I5. Mechanize the purity test wherever possible, including:

(a) Separation of components of lawn and pasture mixtures;

(b) Examination of larger sized samples than the present minimum weights for purity and noxious weed seeds prescribed in the rules;

(c) Movement of seed for macroexamination and microexamination.

I9. Mechanize the germination test wherever possible, for example, an automatic planting system where the counting, distribution of seeds on media, application of moisture, and so forth would be done by machine.

I15. Determine modifications and adaptations of current seed harvesting, conveying, and processing equipment that will minimize mechanical injury to the seeds.

Other Projects Scoring High in Some Respondent Groups

I7. Develop an automatic divider capable of delivering representative subsamples of desired amounts for chaffy grasses and working samples in the 0.5 to 5.0 gram weight range. AOSA (2d), SCST (2d), regulatory laboratories (2d), service testing laboratories (2d), seed technologists (2d).

I11. Determine specifications for seed germination equipment to set practical limits of temperature and humidity within which germination is not affected. SCST (3d), quality control laboratories (3d).

I1. Develop equipment and outline procedures necessary to update seed laboratory office procedures such as receiving and reporting of samples, billing, recordkeeping, and report preparing. ASTA (3d), ISTA (3d).

I14. Design processing equipment utilizing new principles of separation where presently used principles are inadequate even when applied at maximum efficiency. ASTA (2d).

[1] The number in left margin is the number of the project as given in the questionnaire.

Exhibit 7.—Ranking of Subsection Scores Within Major Research Areas by Different Groups of Respondents

Responding group	All replies	Organizational affiliation				Position of respondent			
		AOSA	ASTA	SCST & CSAAC	ISTA	Administrator	Seed tech.	Ext. worker	Res. scientist
Number of responses	515	191	106	65	34	223	134	67	37
Sampling & tolerances:									
Bins, bags, etc.	12	15	7	7	8	13	19	10	10
Processing lines	24	28	18	23	17	25	26	29	18
Homogeneity	18	17	24	25	11	19	21	25	15
Other samp. res.	34	29	39	34	32	35	29	35	33
Tolerances	10	6	17	5	21	12	5	16	12

Exhibit 7.—Ranking of Subsection Scores Within Major Research Areas by Different Groups of Respondents—Continued

Responding group	All replies	Organizational affiliation				Position of respondent			
		AOSA	ASTA	SCST & CSAAC	ISTA	Administrator	Seed tech.	Ext. worker	Res. scientist
Germination:									
Germ. requirements	20	16	26	20	15	20	19	28	32
Physiol & biochem.	7	13	4	17	9	7	18	4	5
Variation in results	14	14	11	16	25	11	15	24	19
Interpret. of seedling	5	3	5	2	7	5	2	13	7
Dormancy	13	12	14	9	10	14	11	6	22
Other research	11	11	13	11	13	13	14	9	8
Supplemental measures:									
Moisture	38	38	28	33	30	38	38	36	37
Vigor	1	2	2	4	1	2	3	1	1
Hard seed value	42	40	44	43	42	41	42	44	46
Quick viab. tests	29	25	32	22	28	28	24	27	29
Detect. chem. treat	39	33	40	37	36	39	36	37	39
Eval. preinoculated seed	44	43	42	45	46	43	45	45	43
Reporting supp. meas.	45	45	41	40	45	44	44	43	42
Storage:									
Preserv. of quality	2	4	1	3	2	1	4	3	3
Predict. storability	19	27	12	24	24	16	27	18	16
Biochem. of aging	28	32	23	27	29	29	33	8	25
Grain quality	46	46	45	46	41	46	46	42	41
Pathology:									
Detect. & ident.	6	5	6	14	3	6	7	5	10
Estab. & transmission	25	31	15	32	31	24	30	12	24
Action & importance	31	30	25	42	23	33	37	17	14
Intercept. & elimin.	33	34	22	39	35	34	34	14	36
Other research	43	44	40	44	44	45	43	41	45
Analytical purity:									
Prep. working samples	23	20	34	18	20	22	17	38	40
Sep. comp. parts	3	1	10	1	5	3	1	10	11
Seed identification	22	19	35	15	18	27	12	34	26
Weeds	26	24	27	21	27	26	25	26	30
Varietal purity:									
Classif. of problems	9	7	21	8	16	8	6	22	6
Using present inform.	30	22	37	26	33	31	20	32	27
Laboratory tests	8	10	20	13	4	9	13	7	4
Greenhouse & field tests	21	21	31	38	12	23	28	15	17
Maintain var. purity	36	41	30	41	37	40	41	31	21

Exhibit 7.—Ranking of Subsection Scores Within Major Research Areas by Different Groups of Respondents—Continued

Responding group	All replies	Organizational affiliation				Position of respondent			
		AOSA	ASTA	SCST & CSAAC	ISTA	Administrator	Seed tech.	Ext. worker	Res. scientist
Production & processing:									
Seed preinoculation	40	42	29	36	39	37	40	40	35
Chemical treat.	35	39	19	30	34	32	32	30	38
Seed production	4	8	3	6	6	4	9	2	2
Blending	37	36	37	29	38	36	39	33	28
Mech. damage	17	26	8	19	22	18	22	11	9
Equipment:									
General lab. equip.	32	23	33	31	26	30	23	39	34
Purity analysis	15	9	36	10	14	17	8	23	31
Germination	16	18	16	12	19	15	16	21	23
Exhaust	41	37	46	35	43	42	35	46	44
Cleaning & processing	27	35	9	28	40	21	31	20	20

Exhibit 8.—Categories for Which Separate Analyses Were Made

Group	Major categories	Number of responses
	Organizational affiliation	
1	AOSA	191
2	ASTA	106
3	SCST & CSAAC	65
4	NASDA	15
5	ISTA	34
6	Others	104
Total		515
	Laboratory classification	
7	State of Federal regulatory	152
8	Commercial testing	31
9	Seed company	143
10	State experiment station	79
Total		405
	Laboratory function	
11	Regulatory testing	147
12	Service testing	79
13	Internal quality control	126
14	Research	83
Total		435

Group	Major categories	Number of responses
	Position of respondent	
15	Administrator or laboratory head	223
16	Seed technologist	134
17	Research Scientist	67
18	Extension worker	37
Total		461

Subcategories
Identification

Group	*Organization*	*Function*	Number of responses
19	AOSA	Regulatory testing	127
20	AOSA	Service testing	29
21	AOSA	Research	28

Group	*Organization*	*Respondent position*	Number of responses
22	Other	Administrators	43
23	Other	Research scientist	22
24	Other	Extension workers	26

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